AY 2002-2003

SIZE MATTERS:

BARRIERS TO ENTRY IN THE MICROELECTRONIC INDUSTRY

ECONOMICS

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Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
2003	**N/A**	**-**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
Size Matters: Barriers to Entry in The Microelectronic Industry	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
David /King	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)	8. PERFORMING ORGANIZATION REPORT NUMBER
The Industrial College of the Armed Forces National Defense University Fort McNair Washington, DC 20319-5062	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release, distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			
unclassified	**unclassified**	**unclassified**	**UU**	**10**	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

INTRODUCTION

The semiconductor manufacturing industry is facing significant and growing barriers to entry that could drive certain market segments toward overcapacity or non-contestable oligopoly. Currently conditions warrant only limited government, action, but U.S. policy-makers should continue to monitor the industry.

DEFINING THE RESOURCE ALLOCATION PROBLEM

For the free market to allocate societal resources efficiently, firms must be able to move resources into and out of the market freely. Impediments that make it very difficult or very costly for a new firm to enter a market and compete with an established firm are called "barriers to entry." The significant and growing barriers to entry (and exit) in the semiconductor manufacturing industry can lead to market distortions and sub-optimal allocation of resources.

Origins and Causes

Barriers to entry in the semiconductor, industry arise from numerous sources, including intellectual property protections, first mover advantages, branding (e.g. the "Intel Inside" marketing campaign),. large sunk costs, and large economies of scale. While economic theory suggests that all barriers to entry lead to less efficient resource allocation, some barriers such as intellectual property protection may be desirable to "incentivize" innovation. However, two of these barriers could cause sufficient market distortions to warrant government attention.

Capital Costs. To retain market share, large firms must produce state-of-the-art semiconductors with the smaller linewidths that allow greater memory/processing capacity and operating speed. First producers of "next generation" chips can charge "premium" monopolistic prices until followers achieve technical parity and enter the

market. However, firms need new equipment to produce each new generation of chips. Thus, chipmakers must continually reinvest.

Equipment and facilities costs are extraordinarily high, however. Standard and Poor's calls the semiconductor industry a " 'no-limit poker game' in which participants invest enormous sums but have no guarantee of earning adequate return."' A state-of-the-art semiconductor fabrication plant currently costs $2-3 billion; in the future, such a "fab" plant may cost as much as $10 billion."' Only large firms have the revenue and sales volume to keep such an investment cycle going.

in addition, the high sunk costs mean that during periods of weak demand, firms, may continue to operate when chip prices fall below average total cost. Because companies can not easily withdraw their investment or transfer these assets to other uses if profits decline, the high cost of the fab plants represent a significant barrier to entry and exit.

Economies of Scale. New technologies allow semiconductor firms to achieve meaningful increases in economies of scale. Production costs vary with the number of semiconductor wafers used, so if a firm can produce more usable chips per wafer, average variable costs per *chip* decline.

Firms can increase the number of chips per wafer by making smaller chips or by using bigger wafers (or both). As mentioned above, the need for speed already drives companies to smaller linewidths (and hence smaller chips). Industry analysts note that chip manufacturers who don't need the speed advantages will still migrate to 0.13-micron chips to achieve the associated cost savings."' In addition, switching from the current standard 200-millimeter (mm) wafer to a 300-mm wafer allows very considerable economies of scale. Chipmakers can place more than twice as many chips on a 300mm wafer, but the costs of processing that wafer are only 20 percent more.' To make the

switch to 300 mm wafers, however, companies need new equipment and, often, entirely new facilities." Again, this investment only makes sense for a large producer that has enough market-share to take advantage of the additional capacity and economies of scale.

Implications

Overcapacity. These barriers to entry have led to manufacturing overcapacity -- particularly in wafer "fabs" that produce 0.2 micron and larger linewidth chips.' This excess capacity indicates inefficient allocation of resources."

Oligopoly. The high barriers to entry have already led to *de facto* oligopolies in two large segments of the semiconductor market -- Dynamic Random Access Memory (DRAM) chips and microprocessors. Samsung, Micron, Hynix, and Infineon -- control almost three-fourths of the DRAM market,"' while Intel alone controls more than 80 percent of the microprocessor market.'"

This market concentration may permit heavy-handed business practices. For example, "since Intel supplies its chips to computer, hardware makers on an allocation basis during periods of tight supplies, disloyal. customers face the prospect of having restricted access to chips during periods of strong demand." Although AMD remains Intel's top challenger, Intel's dominance and personal computer-maker's fears of endangering that relationship have been considerable obstacles to AMD's market penetration."

Move to Fabless. Furthermore, the severe decline in demand and the significant barriers to entry have encouraged many chipmakers to reduce fixed costs (and thus risk) by outsourcing production to third party foundries. An estimated such 1000 "fabless" companies are operating world wide, and even the largest chipmakers such as Texas Instruments, Motorola, and AMD are contracting out some of their manufacturing to third party foundries'."

These foundries offer state-of-the art manufacturing capacity. They are able to combine orders from multiple customers to achieve the economies of scale. Scale economies also arise from the "shortened" learning curves associated with having a diverse customer base: each customer gets the benefits of lessons-learned on a previous ' customers' product. Again, the foundry market is highly concentrated: two Taiwan foundries account for 60-70 percent of the fabless business.

Migration Overseas. Some foreign governments are reducing the capital costs for firms operating in their territories. Foreign government' subsidies, either in the form of tax incentives or direct contributions to plant construction, encourage firms to locate new manufacturing capacity offshore. About one-third of all semiconductor manufacturing is now located in the East Asia/ Pacific (mostly South Korea, Taiwan and China) and the East Asian market share is growing."""

U.S. **GOVERNMENT RESPONSE?**

Absent significant market failures, the market will allocate resources more efficiently than government policy. Government policy can address such market failures, but the government should proceed cautiously. Second and third order effects can stifle innovation and economic growth or lead to even worse resource misallocation.

Governments often have goals other than efficient allocation of resources, however. Thus, the U.S. government might act to achieve economic or political goals such as avoiding abuses of market dominance, countering "unfair" foreign competition, or maintaining desirable levels of U.S. production to satisfy national security concerns. In addition, the U.S. might wish to avoid concentration of production in a single area of the world; dependence on Mid-East oil has taught us the perils of a world supply that depends on regional geo-political stability.

Current conditions do not compel drastic action at this time, however. Despite the

market distortions, competition is alive and well. Capital costs and economies of scale have not yet led to natural monopoly (which occurs when the market can efficiently support only one producer); and no single producer is yet able to use its market dominance to "monopolistically" restrict output, to increase, prices/profit. Overt antitrust violations are not apparent. Foreign subsidies of chip manufacturing, while technically "unfair," actually subsidize U.S. consumers *so* may provide net benefits to the U.S. public. In some cases, U.S. firms received these "unfair" foreign subsidies. Moreover, except in *a* few select areas such as radiation hardened electronics, there seems to be adequate domestic and "secure" foreign sources for' national security needs.

Possible economic strategies

Nonetheless, barriers to entry can'distort markets. Therefore, it is reasonable to consider policies that could reduce the barriers to entry in the U.S yet have minimal disruptive effects on the overall economy. The following policies meet these criteria.

Antitrust enforcement. Antitrust policies can *hurt* U.S, competitiveness by blocking companies from achieving economies of scale. The U.S. needs to assure that dated antitrust policies don't unduly restrict companies. At the same time, however, the U.S. needs to watch for abuses of market power. Intel's use of market power to stifle competition does not appear to have violated any antitrust laws, but given their market dominance, U.S. policy makers will need to keep a watchful eye on their business practices.

Tax policy. Today, firms can depreciate semiconductor-manufacturing equipment over five years, but it only has a three-year economic life."" The U.S. should assure that depreciation of capital investment for tax purposes is commensurate with actual useful life of that capital. This would lower the after-tax cost of capital (and thus entry barriers), and make investment in U.S. facilities more attractive.

Government-Industry Partnerships via direct investment or loan guarantees to meet specific national security needs. Such partnerships should be used *very* sparingly. Any government investment has opportunity costs, so such investments should occur only when there is a particularly compelling case. Government investments can also cause even greater inefficiencies in resource allocation. If the government gives such "subsidies" to a few producers, then it is picking winners and losers - something it doesn't do well. If the government gives "subsidies" to every producer, it encourages overcapacity.

Monitor geographical concentration. The increasing concentration of semiconductor manufacturing in East Asia, while not yet pressing, may be a problem in the future.

CONCLUSION

Barriers to entry do exist, and consequently, this industry does not allocate resources with perfect efficiency. Nonetheless, there is no compelling need for drastic government action. Only limited actions to redress the entry barriers are warranted now, but policymakers should closely monitor developments.

i. Thomas Walter Smith, *Standard and Poor's Industry Surveys: Semiconductors, 9* Jan 2003, 18.

ii, ibid., 18

iii. Richard S. Tortoriello, *Standard and Poor's Industry Surveys Semiconductor Equipment, 13* February 2003, 4

iv. Otis Port et al, "Chips On Monster Wafers: The Megabillion Dollar Cost of Next Generation 'Fab` Plants has the Industry Headed for a Crunch," *Business Week,* 3806, 4 November 2002, *122-126.* Online. Proquest. Retrieved April 2003, 1.

Since 300mrir equipment is generally much bigger than 200mni equipment, 300mm equipment won't always fit in existing facilities.

vi. Richard S. Tortoriello, *Standard and Poor's Industry Surveys: Semiconductor Equipment,* 13 February 2003,2

vii. There generally isn't a market for this overcapacity. Most companies who want to contract out production would prefer to use the state of the art foundries that can achieve lower production costs. Most excess capacity is not state of the art. In addition, companies have intellectual property (IP) concerns with contracting out -- the foundries are known to preserve IP. Also, companies fear their products will receive a lower priority, and that they won't get products when needed.

viii. Peter Clarke, "Micron, Hynix Lose DRAM Market Share Says Dataquest," *Semiconductor Business News, 17* December 2003. Online. Internet. http://www.siliconstrateizies.com/storv/OEG20021217SO03. Retrieved April 2003.

ix. Thomas Walter Smith, *Standard and Poor's Industry Surveys: Semiconductors, 9* Jan 2003, 11

x. ibid., 12

x'. ibid., 12

xii. Russ Arensman, "Fabless Goes Global", *Electronic Business, 1* February 2003, 54-60. Online. Lexus-Nexis Academic Universe. Retrieved April 2003, 1

xiii. ibid., 5

x" Semiconductor Industry Association, "Promoting Economic Recovery and Long Term Growth," *SIA Backgrounders, 19* February 2003.